CUORE (Cryogenic Underground Observatory for Rare Events)

R.J. McDonald, E.B. Norman, A.R. Smith, E.E. Haller and J.W. Beeman**

CUORE (Cryogenic Underground Observatory for Rare Events) is designed to be a large (750kg) array of 1000 TeO_2 crystals to search for rare events, particularly for the neutrinoless double beta decay of ^{130}Te. This experiment will succeed the recently completed MiBeta experiment and the Cuoricino experiment (62 crystals) under construction.

Work in three major areas proceeded for this experiment: 1) construction of the last tests of the MiBeta experiment, 2) crystal polishing for Cuoricino, and 3) continued work on NTD Ge thermistors.

One of us (McDonald) spent a total of 9 weeks at the Laboratorio Nazionale del Gran Sasso working on the final tests utilizing the MiBeta apparatus, an array of 20 3x3x6 cm TeO2 crystals. The goal of this test was to determine if background could be reduced by using ultra-clean copper in the assembly and by lapping away 30 microns of surface to reduce observed surface radioactivity. We also designed a borated polyethylene neutron shield predicted to reduce neutron-induced background by about 30%. These tests have now been completed, and results are being analyzed.

Two of us (Norman and McDonald) spent a total of 9 man-weeks at the Universita' dell' Insubria in Como polishing crystals for the Cuoricino experiment. A variety of hand and machine polishing techniques were tried. As delivered from Shanghai, the crystals were not lapped to the extent expected, and the process of rough lapping had to be repeated. Final lapping was done by hand on two different polishing cloths, resulting in uniformly opaque surfaces. Tests at the Gran Sasso indicated that optically clear surfaces were not required for adequate detector performance.

The thousands of nearly identical thermistors needed CUORE will be produced by the neutron transmutation doping (NTD) of natural germanium. This involves subjecting Ge to about 3×10^{18} neutrons to produce doping levels of about 1×10^{17} Ga atoms per cm^3, 3×10^{16} As atoms per cm^3 and 2×10^{15} Se atoms per cm^3. The word "about" as used here implies only that the absolute numbers are not well determined, whereas precision on the order of 1% will be required to produce thermistors with characteristics close enough to be used.

Our efforts have mainly been focused on studying monitor foils to determine the thermal and epithermal flux in the reactor and the predicted production of dopants. The goal is to use monitor foils as proxies for the production of dopants since the electrical properties of the thermistors cannot be measured for one year or more after the irradiations because of the 11.2 day half life of Ge-71.

One test involved irradiations at the MIT research reactor. This reactor has the advantage of a D2O moderator that essentially eliminates the epithermal portion of the neutron spectrum. Foils of Cr, Fe, and Zr confirmed the absence of epithermal neutrons. Further tests need to be performed to find a part of the reactor with constant and uniform neutron flux to produce large numbers of identical thermistors.

A second test involved increasing the doping of Ge originally irradiated two years ago. Unfortunately, Zr foils were not used at that time, and there was some uncertainty about the neutron flux and spectrum. The additional irradiation was aimed to span the predicted doping. These samples are not sufficiently decayed to test their electrical properties.

Throughout these tests, we continue to build experience that will lead to the protocols for producing the numbers of thermistors needed for CUORE.

Once Cuoricino is taking data, we expect to prepare a full proposal for CUORE in partnership with the Milano Group.

* Material Sciences Division, LBNL